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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	Thomas G.B. Mason et al.	Examiner:	Dung T. Nguyen
Serial No.:	10/049,362	Group Art Unit:	2828
Filed:	February 6, 2002	Docket:	G&C 30794.61-US-WO
Title:	TUNABLE LASER SOURCE WITH INTEGRATED OPTICAL MODULATOR		

DECLARATION OF THOMAS GORDON BECK MASON UNDER 37 C.F.R. § 1.131

I, THOMAS GORDON BECK MASON, declare as follows:

1. I am a named co-inventor on the patent application identified above, and am authorized by the Assignee to make this declaration.

2. Prior to September 2, 1999, we conceived the invention and thereafter diligently reduced it to practice in this country as evidenced by the following:

(a) We conceived the invention described in the above-identified patent application in this country prior to September 2, 1999, as evidenced by the "Disclosure and Record of Invention Form" document attached hereto as an exhibit. The "Disclosure and Record of Invention Form" document describes our invention, and fully supports the claims in the above-identified patent application.

(b) Although the dates on the "Disclosure and Record of Invention Form" document are redacted, the date of conception in item #5 on page 6, the date of first written record in item #6 on page 6 and the date of the first successful test in item #7 on page 6, are all prior to September 3, 1999.

(c) Development of the invention proceeded on a continuous basis from prior to September 2, 1999, eventually culminating in the filing of the United States Provisional Patent Application No. 60/152,432, on September 3, 1999, the PCT International Patent Application No. PCT/US00/23710 on August 29, 2000, and the above-identified United States Utility Patent Application No. 10/049,362 on February 6, 2002.

4. I further declare that all statements made herein of my own knowledge are true and all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: 3/24/05

Thomas Gordon Beck Mason

30794.61-US-WO

University of California

Office of Technology Transfer

Instructions for Completing

DISCLOSURE AND RECORD OF INVENTION FORM

The following instructions apply to the correspondingly numbered sections of the University of California - Office of Technology Transfer Disclosure and Record of Invention Form.

1. Create a short title, sufficiently descriptive to identify the general nature of the invention without revealing specific details that would enable others to reproduce it. A four- to eight-word length is about right.

2.A. Provide a brief summary which addresses the essential nature of the invention and which would enable another person working in the field to reproduce the invention. Point out its novel features and advantages.

2.B. Use additional sheets to provide a complete description which should cover the following points:
a) general purpose or utility;
b) brief description of the state of the art prior to your invention;
c) technical description including drawings, schematics, sketches, flow diagrams, etc., as appropriate;
d) describe the best way of practicing the invention;
e) possible modifications and variations on the best way;
f) advantages and improvements over existing practice, and the features believed to be new.

Do not withhold any key elements of the invention, as a complete description is essential to an enforceable patent.

3. As funding often carries patent obligations, be sure to include all outside agencies, organizations, or companies that actually provided any supply, or expense funding to any inventor for the research that led to the conception or first actual reduction to practice of the invention. (Do not list any funding source gratuitously.)

NOTE: Failure to provide complete information on funding sources may result in delayed processing of your disclosure and/or difficulty in the University's fulfilling its legal obligations to research sponsors.

4. "Inventors" (who sign under item 13) not employed 100% by the University may also have obligations to their employers which will require coordination. Please identify these other employers. For example, Veterans Administration employees must submit VA disclosure forms to the local VA facility as well as disclosing to the University.

5-9. This information is legally important for determining priority of inventorship and / or legal "bars" to patenting. As a general rule, public disclosure, in any manner, before the date a formal patent application is actually filed in a national patent office, automatically destroys patent rights in most foreign countries. Receipt of your Disclosure and Record of Invention Form by the Office of Technology Transfer (University Patent Office) is not the same as the filing of a patent application. (While United States patent law allows inventors up to one year to file patent application after first printed publication, public use or sale, the loss of foreign rights often is very important to potential industrial licensees.)

10. List literature references that most closely describe the state of the related art prior to your invention. While you are not required to make a search of the literature, such a search by you will assist in the evaluation of your invention.

11. Please attach a copy or summary of any written or oral agreement, such as a biological materials transfer agreement, into which you or other University personnel entered in order to obtain any proprietary material used to make or develop your invention.

12. (Optional) Based on your knowledge, please provide the names and addresses of companies that are, or may be, interested in manufacturing, using, and / or further developing your invention.

13. Complete the requested information, and obtain signatures of the inventors. List as inventors those individuals who, individually or jointly, contributed either to the conception or reduction to practice of your invention. In the event that a patent application is filed by the University, actual inventorship will be determined as a matter of law by a patent attorney. (Do not list any inventor gratuitously. The rules for inclusion are not the same as a scientific publication.)

14. Obtain the signatures of two technically qualified witnesses who have read and understood the Disclosure and Record of Invention Form. Use University of California employees whenever possible.

NOTE: ORIGINAL SIGNATURES are required for items 13 and 14. If a co-inventor is not available to sign due to unavoidable circumstances, please so indicate.

If you would like assistance in completing this Disclosure and Record of Invention Form, please call the Office of Technology Transfer at (510) 587-6000. We are here to assist you.

Please submit the original completed Disclosure and Record of Invention Form, with signatures to:

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1. Short descriptive title of the invention.
Tunable Laser Source With Integrated Optical Modulator

2. A. Briefly summarize the invention here. Include the novel features and advantages.
The invention is a simple and effective method for creating a tunable laser source with an integrated optical modulator that can be fabricated on a single semiconductor chip. The source can be rapidly tuned over a wide wavelength range enabling it to be used in a variety of applications from wavelength division multiplexed fiber optic communications to phased array radar. Integrating a modulator with this source provides a highly desirable method for modulating the intensity of the output light without perturbing the mode stability of the laser or introducing high levels of frequency chirp. It also enables much higher modulation frequencies to be reached than is possible with just the laser. The invention includes both the design of the device and a highly desirable method for fabricating it. The device includes a widely tunable sampled grating distributed Bragg reflector laser and an electro-absorption modulator. The modulator and the laser share a common waveguide which is designed to provide high index tuning efficiency in the laser and good reverse bias extinction in the modulator. A separate multiple quantum well layer on top of the waveguide provides the optical gain in the active section of the laser.

B. Detailed description of the invention using additional sheets as necessary and attach as appendix.
The sampled grating distributed Bragg reflector laser is a promising device for use in wavelength division multiplexed fiber optic communication systems. It is a more complicated device than the conventional distributed Bragg reflector lasers which are currently used. It is a four section device which incorporates two tuning mirrors a gain section and a phase control section (Figure 1). The principle advantage of these lasers is that they can be rapidly tuned over a wide wavelength range by proper adjustment of their control currents (Figure 2). This is a highly desirable feature which makes them useful for current and next generation fiber networks. In order to achieve this wide range tuning, these devices require fairly large passive tuning elements. This makes them four to five times larger than conventional fixed wavelength lasers. Having this large amount of passive material in the laser cavity reduces the speed with which they can be turned on and off. This limits the rate at which they are able to transmit data making them unsuitable for high bandwidth applications.

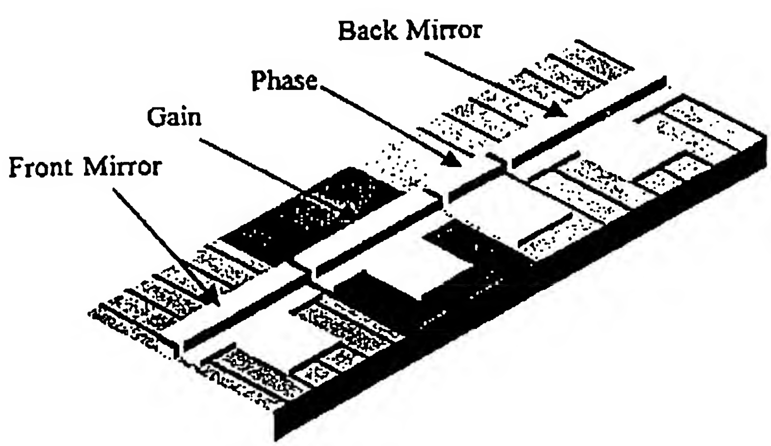

Figure 1. Sampled Grating Distributed Bragg Reflector Laser

There are two other factors that make it difficult to use these devices to transmit data. The wavelength in the sampled grating distributed Bragg reflector laser is controlled by aligning a pair of reflection peaks in the two mirrors with an optical cavity mode. When the gain current is modulated over a wide range of currents it can disturb this alignment resulting in mode instability within the device which is highly undesirable for data transmission. To prevent this mode instability the devices can only be modulated over a narrow range of output powers which introduces a significant extinction ratio penalty to their data transmission performance. The other problem with directly modulating the laser is frequency chirp, which is the shift in the laser oscillation frequency that occurs when it's output power level is changed. This is undesirable in transmission systems since it causes pulse spreading, which limits the maximum distance over which data can be sent.

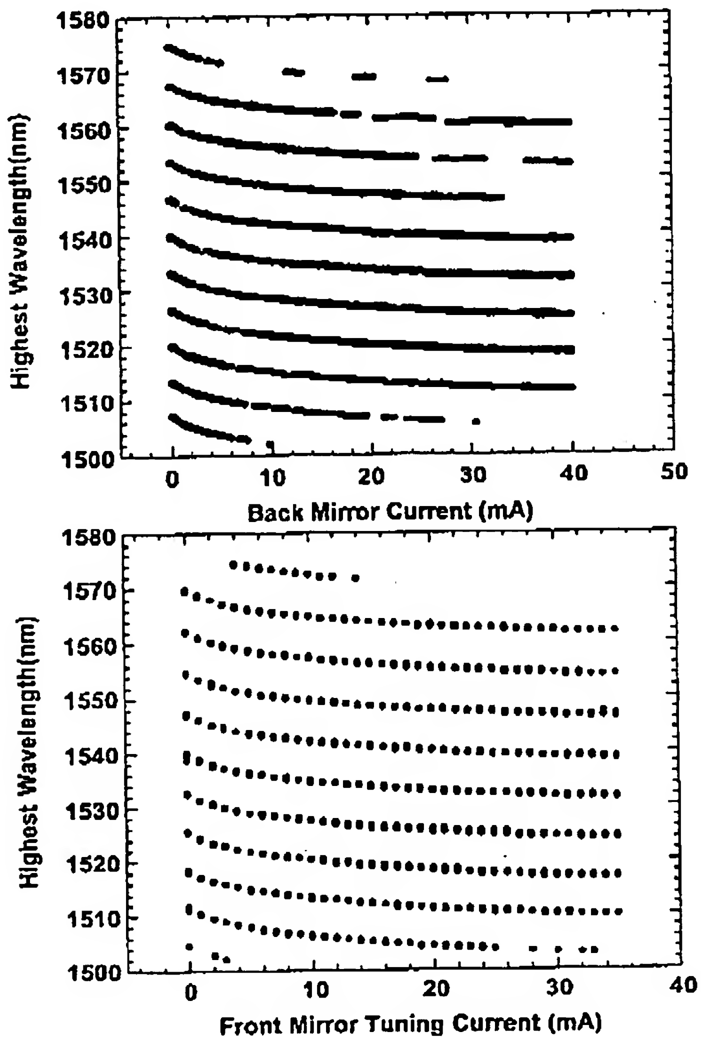

Figure 2. Tuning curves for wide range wavelength tuning

Description of Invention

We have developed a unique design for a widely tunable laser with an integrated modulator. This design enables an efficient and low cost fabrication process to be used to make both the laser and modulator together on a single semiconductor chip. The key to this design is in the transverse structure of the waveguide. A single common waveguide layer is used for the tuning sections in the laser and for the modulator. A multiple quantum well active region is grown on top of this layer separated by a thin stop etch. The active layer is removed from the tuning and modulator sections with a selective wet etchant prior to regrowing a cap layer on the device. A cross section of the device waveguide structure is shown in Figure 3.

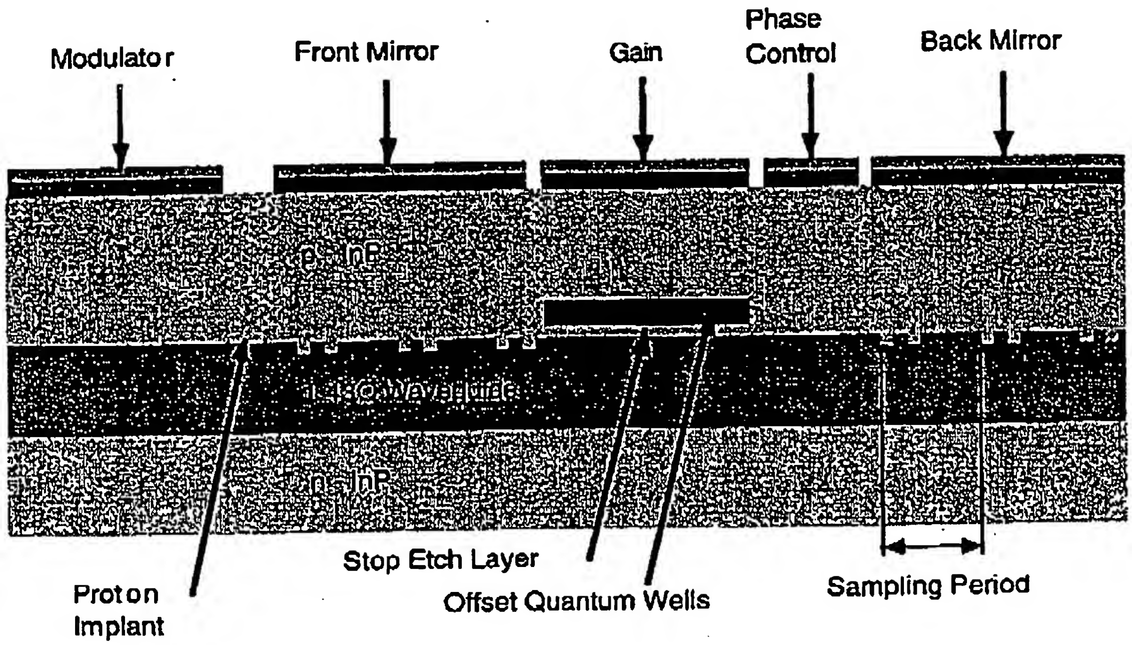

Figure 3. Cross section of integrated laser modulator

The device performance is optimized by using a thick, low bandgap waveguide layer. This provides good index tuning efficiency in the mirror sections and a reasonable extinction ratio and chirp parameter in the modulator. The operation of the modulator is based on either the Franz-Keldysh effect in a bulk semiconductor waveguide or on the quantum confined Stark effect in a multiple quantum well layer. When a strong electric field is applied to the waveguide the band edge of the material is shifted to lower energies allowing it to absorb the output laser light (Figure 4). This technique allows very rapid modulation of a device with minimal wavelength chirping. Under the correct conditions this can produce sufficient optical loss to extinguish the output light intensity by more than 20 dB even over a wide wavelength range. For narrower ranges of operation a multiple quantum well modulator could be used grown into the center of a higher bandgap waveguide. This would provide less efficient tuning in the laser but would allow for lower voltage operation in the modulator since the bandgap detuning can be reduced due to the sharper absorption edge of the multiple quantum well structure.

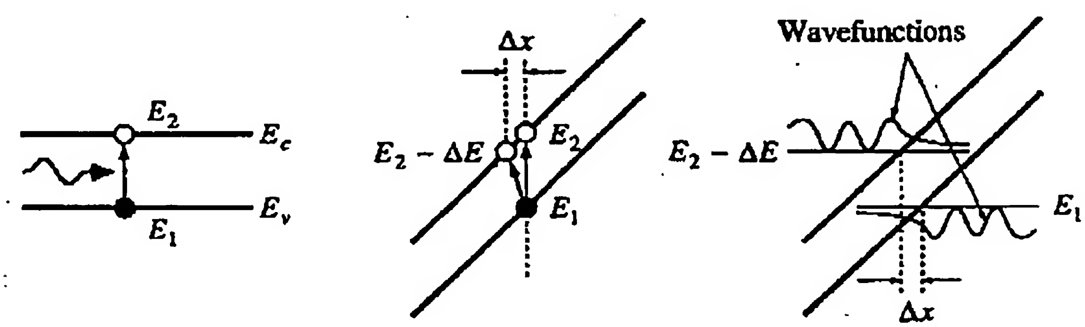

Figure 4. Franz-Keldysh effect in modulator

A schematic of an integrated laser modulator is shown in Figure 5. In this preferred embodiment the device would incorporate a buried heterostructure waveguide with an Fe-n-p blocking junction. The Fe blocking junction blocks lateral current leakage in the laser and reduces the parasitic junction capacitance of the modulator. Initial tests of a buried heterostructure electro-absorption modulator integrated with a sampled grating distributed Bragg reflector laser were conducted to demonstrate this invention. In these tests a 400 nanometer thick waveguide with a bandgap wavelength of 1.4 microns was used. The laser had a tuning range of more than 47 nanometers. The modulator was able to produce more than 26 dB of extinction over this entire tuning range with only a 4 V bias (Figure 6).

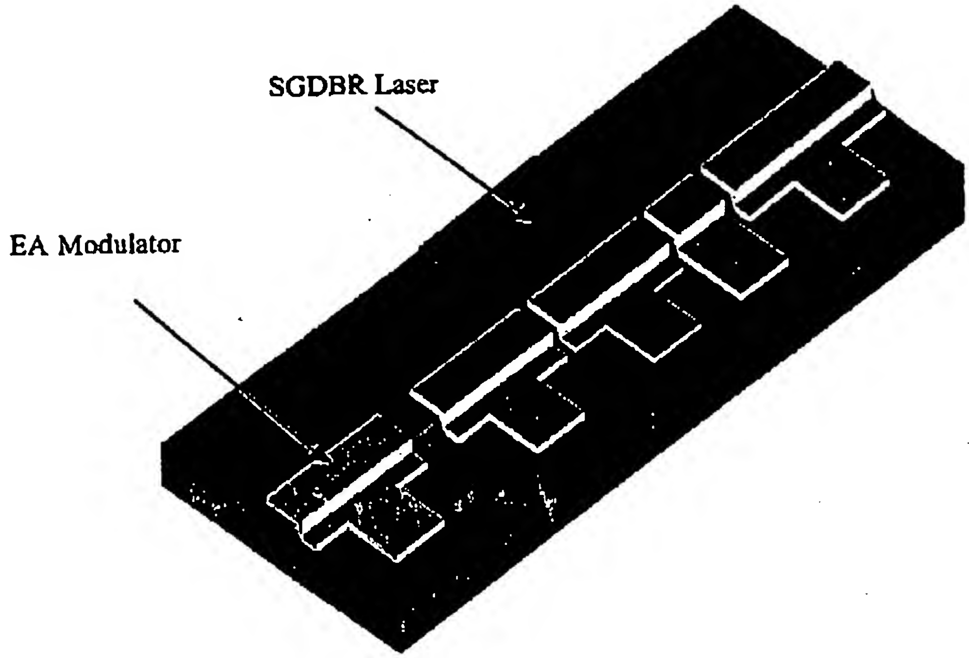

Figure 5. Schematic of buried sampled grating distributed Bragg reflector laser with Integrated electro-absorption modulator

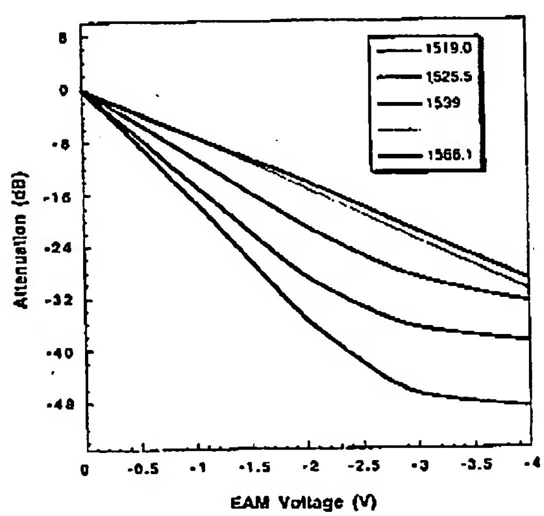

Figure 6. Response curves for integrated laser modulator over a 50 nm tuning range

3. List the funding source(s) for the project under which this invention was made. If applicable, identify by contract or grant number and name the Principal Investigator/Supervisor of each.

Funding Source/Sponsor	Contract or Grant Number	Principal Investigator/Supervisor
Naval Research Labs	N00014-96-1-6014	Prof. L. A. Coldren

4. For any Inventor named (item 13) who is not employed full-time by the University of California, please identify other employers (e.g., Veterans Administration, Howard Hughes Medical Institute, USDA), the percent of salary time funded by such other employer, and the nature of the other employment (such as research, teaching or clinical duties).

5. When did you first conceive this invention?

[redacted]

6. What is the date of the first written record (notebook, letter, proposal, drawing, etc.) of this invention? Identify the document, page numbers involved, and location of the document.

[redacted]

7. When did you first successfully test this invention?

[redacted]

8. If you have disclosed this invention to non-UC personnel (including research sponsor) then indicate when, under what circumstances, and to whom.

a. orally

b. in writing

[redacted]

c. by actual use, demonstration, or posters

9. Have you submitted or do you plan to submit a report, abstract, paper or thesis relating to this invention for publication, for presentation at a conference, or to a research sponsor?
If yes, give details, including the actual or planned date of submission. If a manuscript has been accepted, give the anticipated publication date. Append a copy of the latest draft manuscript available. (See instructions for the effect of publication prior to the filing of a patent application.)

[redacted]

10. Identify any references, patent applications, or other publications of which you are aware and which you believe to be pertinent to this invention. Please attach a copy of each of these references, if available.

11. If any proprietary material (e.g., cell line, antibody, plasmid, computer software, or chemical compound) obtained from outside your laboratory was used to develop this invention under a restrictive written or oral transfer agreement (other than a normal purchasing agreement), please attach a copy or summary of that agreement.

12. List companies you believe might be interested in using, developing or marketing this invention..

13. Signatures, Names, and Addresses of Inventors

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Note: if there are more inventors please provide signatures, names and addresses on an additional sheet of paper.

14. Technically Qualified Witnesses (Two Required) - Invention disclosed to and understood by:

a) ______________________ [redacted]
Signature

Jonathan Barton
Print Name

b) ______________________ [redacted]
Signature

Dan Lofgreen
Print Name

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